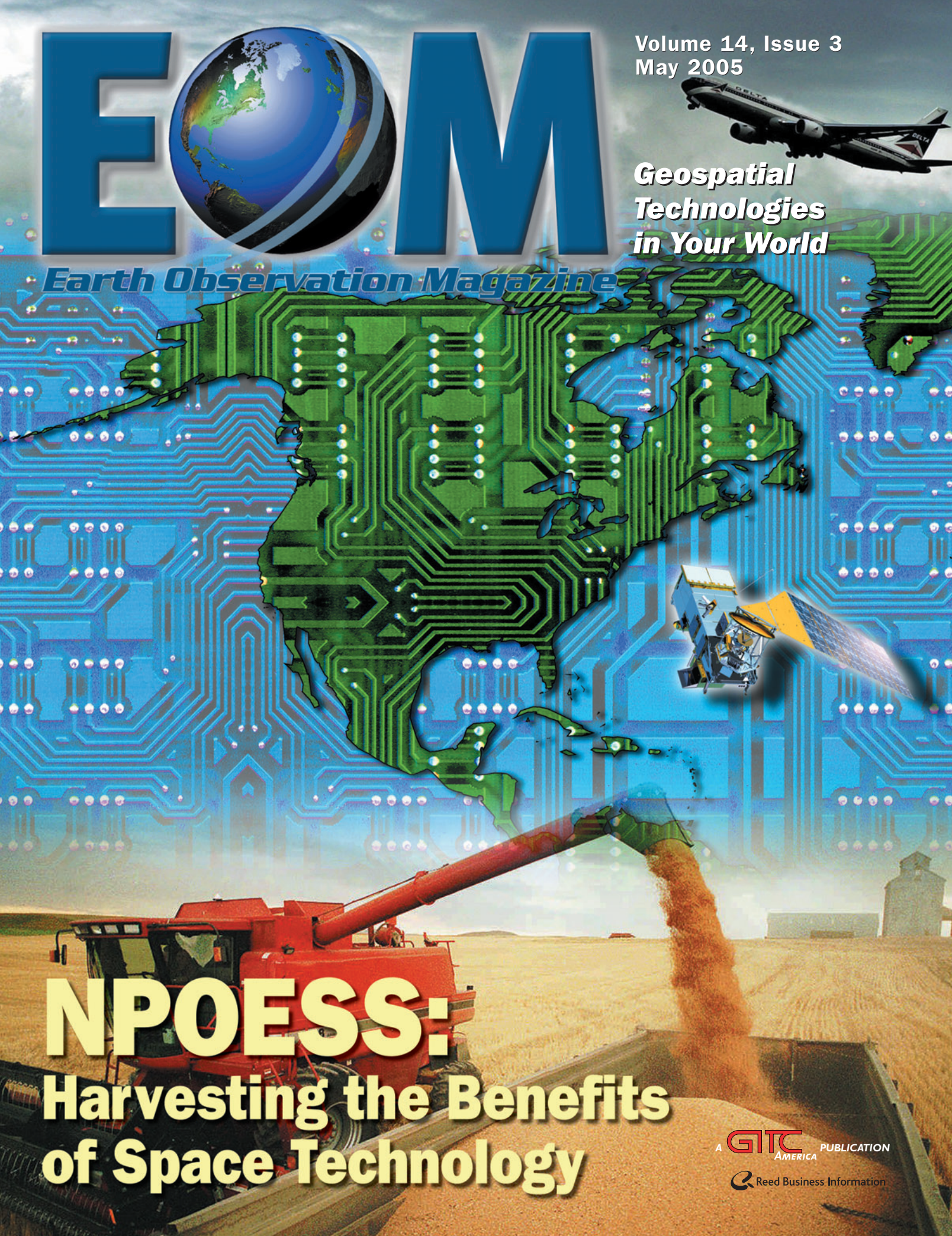
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NPOESS:

Harvesting the Benefits of Space Technology

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Previous articles in this series on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) highlighted the improvements in space-based measurements that NPOESS will provide for the military, for climate modelers, and for weather forecasters to ensure safety, protect life, and save property. NPOESS will also deliver a wealth of environmental information to benefit a range of socioeconomic sectors from agriculture and fishing, to transportation, energy, and the general public.

Introduction

The National Oceanic and Atmospheric Administration (NOAA), the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA) are jointly investing in the National Polar-orbiting Operational Environmental Satellite System (NPOESS) to better monitor the Earth's systems for improved weather warnings and forecasts, to improve climate assessments and prediction, and to enhance natural hazards detection and mitigation. Beginning in late 2009, NPOESS will become operational with a new generation of instruments to improve the accuracy and timeliness of global data used for weather forecasting and environmental monitoring. The American public and many industrial, agricultural, and other important socioeconomic sectors will benefit from NPOESS data.

Land Use Monitoring

Visible imagery from the current generation of polar-orbiting satellites is used to map global indices of vegetation. The U.S. Department of Agriculture (USDA) uses NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) to improve information on important crops around the world and assess the health of agricultural production. As the successor to MODIS, the Visible/Infrared Imager Radiometer Suite (VIIRS) on NPOESS will improve upon currently available vegetation indices and more accurately monitor and detect changes in the condition of the Earth's vegetative cover and land surface types. These improvements will allow us to better map and monitor spatial patterns and seasonal and inter-annual variability in global vegetation, and to enhance agricultural and forestry production.

A recent White House decision added a Landsat-type Operational Land Imager (OLI) to the suite of instruments that will be flown on NPOESS. The combination of VIIRS and OLI will offer powerful, complementary tools for mapping land surfaces at resolutions from 30 to 800 meters. When combined with information on soil moisture and precipitation that will be available from the Conical-scanning Microwave Imager/Sounder (CMIS) on NPOESS, these measurements will provide unique data for monitoring crop stress, deforestation, and desertification globally. Frequent NPOESS-based observations of vegetation will enable the assessment of how natural disasters, such as fires, floods, extreme temperatures, or extended droughts, affect crops. The information provided will play a crucial role in decisions affecting agriculture, trade policy, and international food aid.

Imagery from VIIRS in combination with improved microwave data from CMIS will provide better observations of variability in snow cover and water content, and supply information about the volume of water stored in snow. NOAA uses satellite data in combination with airborne surveys, ground measurements, and models to map the snow properties that are

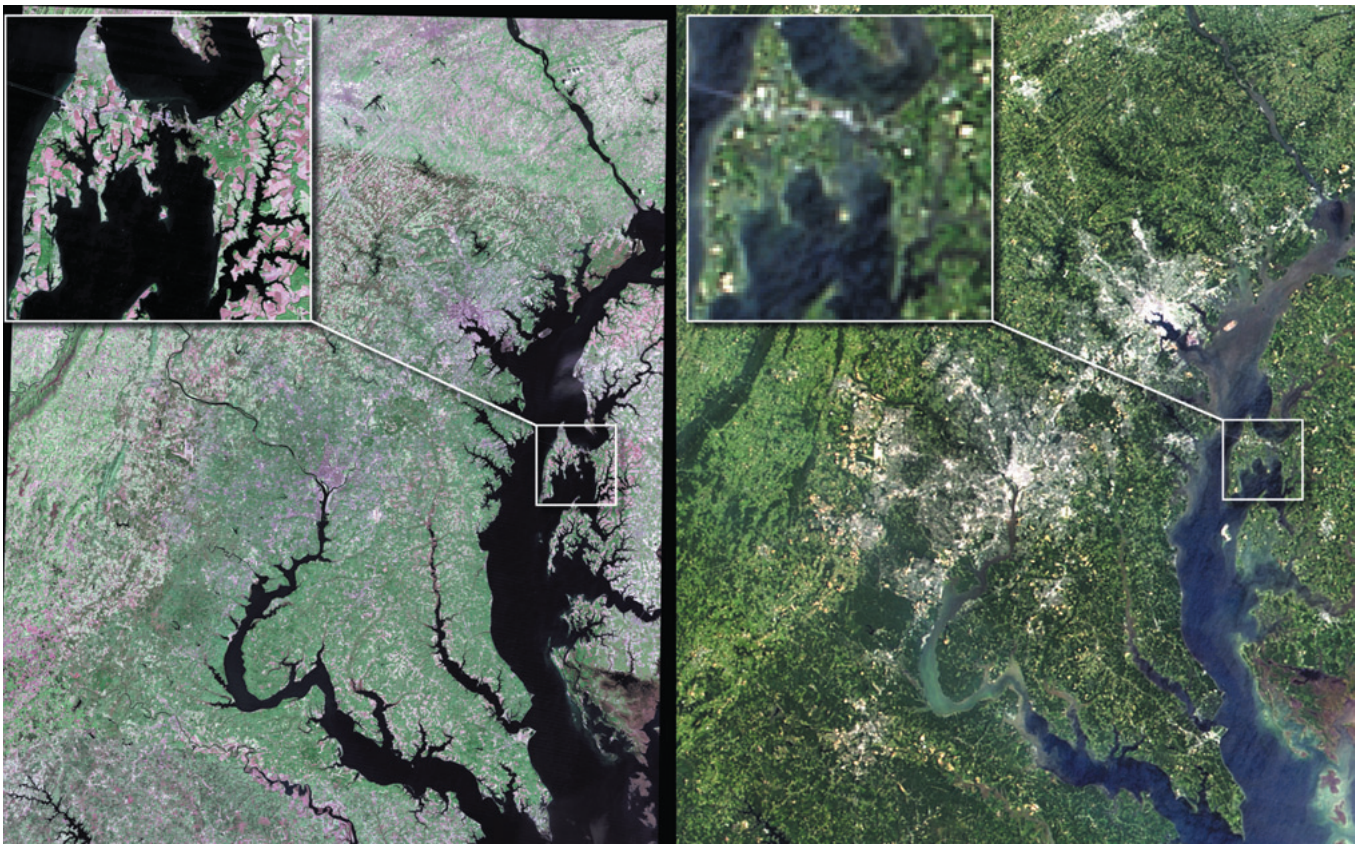

Figure 1 *These two images show the Baltimore, MD–Washington, DC corridor in eastern Maryland captured by the Enhanced Thematic Mapper (ETM+) sensor aboard Landsat 7 (left) and the MODIS sensor aboard Terra (right). The images clearly show the higher resolution of the ETM sensor. The zoom-ins show the Eastern Bay on the eastern shore of the Chesapeake Bay. Notice the sharpness in the ETM image of the different vegetation types in the clearly defined parcels. Part of the Chesapeake Bay Bridge is also visible in both zoom-ins. Having an operational ETM-like sensor on NPOESS will significantly increase operational use of this information. Terra data retrieved from the MODIS Land Rapid Response system, GSFC, NASA. Images processed by StormCenter Communications.*

critical input for forecasting spring snowmelt, a phenomenon that is often responsible for devastating floods. Extended periods of drought can be equally catastrophic to agriculture and severely stress limited water resources. NPOESS will become part of a global early warning system for drought that should allow for better crop management and timing of foreign food aid shipments.

Fish Finding from Space

For nearly 30 years, fishermen have received a helping hand from polar-orbiting satellites that observe changing conditions on the sea surface. Information on sea surface temperature (SST), ocean color, locations of oceanic fronts and eddies, and ocean surface currents can help to identify where the best fishing holes are. SST images and analyses can delineate strong features such as the Gulf Stream, oceanic fronts, and coastal upwelling zones that are often productive fishing areas. Such data can also be used to identify tropical "hot spots" where fragile coral reef systems may be experiencing bleaching due to temperature stress. Satellite observations of ocean color, a proxy for phytoplankton, complement SST measurements and provide oceanographers with a unique view of global as well as regional productivity. NOAA is using ocean color imagery operationally to monitor Harmful Algal Blooms (HABs) in the Gulf of Mexico and off the coast of southwest Florida, where toxic phytoplankton blooms can have devastating effects on shellfish resources and commercial industries. HAB events can lead to extensive fish kills or closure of commercially or recreationally important shellfisheries with potential economic impacts exceeding $400 million and loss of employment for 10,000 persons across seventeen states.

When NPOESS is launched, infrared data from VIIRS will be combined with microwave measurements from CMIS to provide an "all weather" capability to map SST. Blended satellite data and *in situ* measurements will allow oceanographers to monitor global and regional sea surface temperatures at higher resolutions than are currently available today. NPOESS will also be the first operational satellite with an ocean color capability. The combination of ocean color and thermal infrared imagery from VIIRS offers a powerful tool for mapping oceanic features in real-time. Over longer time scales, ocean temperature data are used to monitor the onset and decay of El Niño/La Niña in the Pacific Ocean and are yielding clues about shifts in the "oceanic conveyor belt" that may drive large-scale changes in climate. Strong El Niños often lead to displacement and collapse of productive fisheries off the coasts of

Figure 2 *Agricultural sector will benefit tremendously with operational Landsat-like information. This data will allow for much more rapid crop health assessments, which will minimize the application of fertilizers while increasing crop yield. Minimizing the application of fertilizers will enhance water quality of streams, rivers and bays. Image courtesy: AP World Wide Images*

Peru and Chile, and as far north as California, where winter coastal storms also bring heavy rains causing floods, landslides, and damage to agriculture that often result in significant economic losses. However, understanding and predicting El Niño/La Niña have allowed us to save millions of dollars in the United States alone. Direct losses in the United States of about $4 billion during the 1997-98 El Niño were more than offset by benefits estimated at $19 billion. Worldwide, the benefits to agriculture due to El Niño forecasts may reach $450 to $550 million per year.

Routing Transportation

To keep ships safe from ocean storms and on schedule, the $200 billion global marine industry relies increasingly on routing services that make use of satellite data to derive information on ocean winds, waves, currents, ice, and marine warnings and forecasts to improve vessel routing for safety, fuel savings, and efficient operations. Microwave imagery and sounding products from CMIS input into improved numerical models will enable better ocean transit routing through improved wind and wave forecasts. Data from VIIRS and the radar altimeter on NPOESS will also allow nowcasting and forecasting of ocean currents, which will improve routing of coastal transits as well as ocean crossings. The incremental benefit from commercial ship transit timesavings with NPOESS data is estimated to be on the order of $95 million per year in the two decades following the initial NPOESS launch.

Satellite data are equally important to aircraft routing. The advanced atmospheric sounders on NPOESS will provide more accurate, higher resolution data on the vertical distribution of atmospheric temperature and moisture leading to

Figure 3 *Ship routing for safe transportation and efficient use of fuel is critical for worldwide commerce. NPOESS will supply information and imagery that will improve maritime weather forecast accuracy. Image courtesy: AP World Wide Images*

Figure 4 *Under stormy skies in a break from rain that drenched the area, an airplane takes off from Los Angeles International Airport. Satellites such as NPOESS will provide improved information that feeds into numerical weather prediction models that aid in the routing of airliners worldwide. Image courtesy: AP World Wide Images*

improved forecasts of flight-level winds. Such improvements translate to direct savings in fuel and time for the airline industry. Safety is important to this industry as well. Multi-channel imagery from VIIRS, combined with data from the Ozone Mapping and Profiler Suite (OMPS) and the Aerosol Polarimetry Sensor (APS), will be an effective tool for monitoring the development, advection, and dispersion of volcanic ash plumes, particularly in polar regions where flight routes pass near about 100 Alaskan, Russian, and Japanese volcanoes. The world's Volcanic Ash Advisory Centers issue ash cloud advisories to commercial aviation so that aircraft can be rerouted to avoid potentially catastrophic plumes. Historically, the overall economic risk to the airline industry from airborne volcanic ash effects is about $70 million per year. Airline operations will also benefit from the improved capabilities of NPOESS imagers to discriminate among low clouds, fog, and dust, and of NPOESS sounders to estimate precipitation.

Energy and the Public Sector

In last month's article we discussed how NPOESS space environment sensors will monitor geomagnetic storms that can cause multi-million dollar electrical system failures and disruptions of utility power grids in the United States, Canada, and Europe. The capabilities of NPOESS instruments to monitor other Sun-Earth phenomena, such as solar radiation and the Earth's radiation budget, will also support improvements in energy-sector technologies worldwide. As energy industries integrate more alternative energy sources (*e.g.*, solar power) with traditional power systems, the demand for better information on weather, climate, and solar radiation will increase.

A little known, but critically important payload on NPOESS will be the Search and Rescue Satellite-Aided Tracking System (SARSAT) that is currently carried on NOAA's Polar-orbiting Operational Environmental Satellites (POES). Since 1982, the international Cospas-Sarsat system has been credited with more than 18,000 rescues worldwide, including over 4,900 in the United States alone, with most rescues occurring at sea, according to today's statistics on the NOAA SARSAT website. While the general public ultimately benefits from the investments that are being made in next generation space technologies, such as NPOESS, the agencies involved in NPOESS are realizing significant cost savings and efficiencies through collaboration and convergence of heritage programs. In our next article we will recap how multiple agencies benefit from a single, national system to satisfy both civil and military requirements for space-based remotely sensed environmental data.

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